Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

PHYSIOGRAPHIC NOTES.

BY

RALPH S. TARR.

GEOLOGY AND WATER RESOURCES OF NEZ PERCE COUNTY, IDAHO.—Among the important publications of the United States Geological Survey are the Water Supply and Irrigation Papers, which contain much geographic material of value. They consider the question of the surface water and the underground water supply with especial reference to their usefulness in irrigation; but in connection with the work, great part of which is done by trained physiographers, a great deal of physical geography is presented, much of which is distinctly new. The papers are, as a rule, well illustrated, which adds much to their geographic value. Of these papers numbers 53 and 54, by Prof. I. C. Russell, may be taken as a type; and, in order to call attention to these papers in general, and this one in particular, I propose to abstract his discussion of the water resources of the Nez Perce region somewhat fully.

Nez Perce County is situated in western Idaho, being bordered on the west by both Oregon and Washington. The ground covered in Russell's report extends westward, somewhat beyond the limits of the county. The reason for undertaking the investigation is the fact that this section has an exceedingly fertile, dark, rich soil, resulting from the disintegration of volcanic rocks, and is the seat of a very extensive and rapidly-growing industry of wheat-raising. The climate is admirable, excepting that there is not quite rainfall enough for all seasons; therefore, any addition to the water supply that could be discovered would prove of great value. While the rivers have much water, this is practically inaccessible, because of the fact that the streams are deeply set in cañons, and at present the construction of storage reservoirs is rendered difficult by conflicting interests. For these reasons attention has been directed to possible subterranean sources of water supply, and a number of wells have been drilled, one of which yields a good surface flow. Any light, therefore, that can be thrown upon the underground water supply will prove of great value to the region.

The Nez Perce district is divisible into two very different sections—one in which the structure is a complex of sedimentary, igneous and metamorphic rocks, and the other, and younger, a vast extent of basalt, with included layers of clay, sand, gravel, and volcanic dust. The first and older was greatly disturbed by mountain-building and worn by denudation before the lava was poured out. There is evidence of immense denudation in these older beds, and the land which they form is drained by a well-developed, mature system of water ways. During the glacial period the valleys of these mountains were occupied by local valley glaciers, which, however, do not seem to have united to form a single ice-sheet.

That the pre-Tertiary land was greatly denuded is proved by the peaks, such as Cottonwood Butte, which rise like islands in the sea above the vast floods of lava which fill the Snake and Columbia valleys. These peaks in some cases reach an elevation of over a thousand feet above the surrounding basaltic plateau. The great extent of the denudation by which this old land was carved is further indicated by the fact that the formation of the deep cañons which cut the lava, representing the work of erosion since Tertiary time, is small compared with the task which was previously accomplished in forming the mountain peaks by removing surrounding material. Against these mountains, sheet after sheet of molten rock was poured out, rising higher and higher on the sides, and doubtless completely covering many neighbouring peaks of lesser height. One of these peaks projecting above the lava plain is known as Steptoe Butte; and since it is a typical example of these eminences, Russell proposes the name *Steptoe* as a geographic name for an island-like area in a lava flow.

That the lava floods rest upon a land similar in geological structure to the Steptoes and the neighbouring mountains is proved by the fact that the deep cañons which have been cut in the lava reveal gneiss, schist, quartzite, etc., unconformably beneath the basalt. The geological age of these rocks is not certain, though the few fossils found in them indicate that some of them, at least, were formed in the Carboniferous time.

The basalt, which is known as the Columbia River lava, is a part of one of the most widely-distributed geological formations on the continent. Its exact boundaries have not been traced, but it lies almost entirely within the drainage area of the Columbia valley, forming the surface over nearly the whole of Washington and Oregon, east of the crest of the Cascades, and extending into Idaho until it meets the older formations of the western base of the Rockies. The area of the formation is estimated to be 200,000, possibly 250,000 square miles, and its greatest known thickness more than 4,000 feet.

The accumulation of this immense mass of lava required a long period of time, with intermediate periods in which layers of sedimentary material, principally clays and sands, were accumulated to be covered by later flows.

In places, also, the lava sheets are separated by layers of volcanic dust containing the silicified trunks of trees, which grew on a soil formed by the decay of the underlying layer, thus showing that the intervals between the flows were in some cases a century or more in duration. The lava came through fissures in the earth's crust—in what are known as fissure eruptions—and spread widely over the land, from which it is evident that each sheet was spread out horizontally.

The lava sheets are still essentially horizontal over broad areas, though frequently with gentle dips, and in some areas tilted, and even sharp-folded and faulted. On the eastern slope of the Cascades the dip is towards the east, showing that a large part of that range has been elevated to a height of at least 6,000 feet since the lava was poured out.

The fact that the Columbia river lava came to the surface through fissures as molten rock, and that it spread widely over the land, is shown not only by the generally level condition of much of its surface as it exists to-day, and by the absence of volcanic mountains, cinder cones, etc., in connection with it, but is demonstrated in a most instructive manner where denudation has exposed the dikes formed by the cooling of the liquid magma in the fissures through which it was forced to the surface. Over an area of at least 400 square miles on the eastern slope of the Cascade Mountains in Washington, to the south of Mount Stuart, the lava has been eroded away so as to lay bare the rocks on which it formerly rested. In the surface there exposed many hundreds, probably thousands, of dikes are to be seen. These dikes, composed of dense basaltic rock, range in thickness from a few feet to 160 or more feet, but in general they are from 15 to 60 feet across.

These vast fissure eruptions caused the lava to spread over the land surface like an inundation, covering broad plains and extending far into pre-existing valleys. They differ from the eruptions of volcanoes in this respect and in the absence of cones. Such vast floods naturally seriously interfered with drainage; and that many lakes were formed is proved by the presence of lake deposits between the lava sheets, in some cases of great thickness and wide extent. It is from the plant fossils preserved in these sedimentary beds, and in the beds of volcanic ash, that the age of the lava is proved to be Tertiary. It is probable that the lava did not cease until late in the Tertiary, or even possibly in the beginning of the Pleistocene time. The western margin of this sea of molten rock was west of the present crest of the Cascade Mountains, giving a width of fully 250 miles; that is, a width equal to the distance from

New York City to Rochester. The different layers of lava, of which twelve to fifteen sheets are sometimes exposed in a single section on a cañon wall 2,000 feet high, vary in thickness, being in general from 50 to 150 feet thick in each case. The surface of the plain is covered with a deep residual soil, so completely decayed that one may travel for miles without seeing a rock fragment.

This pile of lava sheets, with their intercalated layers of volcanic ash, lava beds, and alluvial fan deposits, reaching a depth of over 4,000 feet, now has a surface-level of from 3,000 to 3,300 feet. From this it is evident either that the bottom of the valley was at least 1,000 feet below sea-level—as at present is the case in the Dead Sea and Death Valley*—or else that there has been a general subsidence of the region to an amount of at least 1,000 feet; and the facts in the field point toward the latter conclusion. This broad subsidence has not greatly disturbed the original horizontality of the strata.

Russell makes use of the facts in this region for a discussion of their bearing upon the theory of isostacy. The total volume of the Columbia river lava is not far from fifty to sixty thousand cubic miles. Its weight is about 160 pounds to the cubic foot, so that where the lava is 4,000 feet thick its pressure is not far from 320 tons to the square foot. Would the addition of such a mass of rock to the surface cause a regional depression in the earth's crust? Russell considers that the answer would be in the affirmative, and that the subsidence in the region has not been less than 3,500 feet, and probably as much as 4,500 feet. He believes that the downward movement began early in the extrusion of the lava. He calls attention also to the fact that the Cascade Mountains to the west, which also consist in part of Columbia river lava, have been upraised with a dip toward the depressed region. Their present elevation is from 7,000 to 7,500 feet. There has been an uplift also in the east. Thus it seems evident that portions of both the eastern and western margins have been raised to an amount equal to 3,000 to 3,500 feet, while the central part has been depressed to about the same amount from what would have been the surface-level of the lava-covered country, in case there had been no subsidence. "These movements have been in large part of the nature of a tilting of broad blocks of the lava bounded by monoclinal folds and faults."

The drainage of this lava-flooded land is interesting. It is essentially a region of steep-sided cañons, with broad, generally level, remnants of the dissected plateaux between them. After much interference by lava-flows, and many episodes not now understood, a drainage was begun upon the plateau. This was interfered with by changes in level, and some of the streams appear to have maintained their courses across the uplifted parts, being in the nature of *antecedent streams*. This was true, for example, of the Snake river where it crosses the Craig Mountain uplift. But in some cases the uplift was so rapid that the streams were unable to corrade or upgrade their channels as fast as the barrier rose, and these streams were turned from their courses. An illustration of this is furnished by the Grande Ronde river, which was turned aside by the Blue Hills dome; and another by the Clearwater escarpment, which turned the Snake river aside at Lewiston. Other streams are *consequent* upon the monoclinal slopes; and still others have developed their *consequent* courses by headwater erosion. Of these streams the Snake river is the largest in the Nez Perce region. It is characteristically a cañon stream for nearly its entire length of about 750 miles. It is interrupted by falls and bordered by cañon walls reaching from a few hundred to 4,000, and even in one case to 6,000 feet.

---

* The Dead Sea is 1300 feet below the sea-level; Death Valley between 200 and 300 feet.

The cañons are not narrow trenches with vertical walls, but, owing to the variability in the enclosing, nearly horizontal strata, they are widened, especially at the top, and their walls are greatly sculptured by lateral streams. Therefore the topography is often very diverse. In some cases the diversity is due to the underlying, more resistant formations of metamorphic rock; and in this case the cañon form is characteristically that of a part of the Grand Cañon of the Colorado, namely, a narrow cañon at the bottom where the rocks are most resistant, and a broader, outer, and upper cañon where the lava sheets form the wall. The prime reason for the broadening of the valley in the lava-walled portion is the variation in texture from the hard lava to the intercalated beds of lava, volcanic ash, etc. These softer beds, upon being slowly removed, undermine the lava and cause a succession of landslides, which broaden the valley and render the slope less steep and the surface more irregular. There is an instructive discussion of landslide topography in the article.

An episode in the history of the drainage which has been brought forth by Russell's studies is the change which has evidently taken place from a cañon-making stream to one of gravel deposit. The cañons were excavated to a depth of from 2,000 to 4,000 feet; then gravel to a depth of at least 230 feet and probably 360 feet was laid down. These have subsequently been re-excavated, and these streams have again begun their tasks of cañon-making. The explanation of this change from corrasion to aggrading in the case of swift rivers with high grade seems to be the supply of gravels furnished during the glacial period. At that time precipitation was probably increased beyond what it was before or what it has been since; and this, added to the supply of water from the melting of the glaciers, gave to the rivers such a load of detritus that they became overburdened and began aggrading their courses. With the disappearance of glacial conditions the rivers returned to their normal work of corrasion, and have not only cut out much of the gravel, but have set to work on the under rock. The gravel remains in places in terraces on the river side.

Russell does not consider the problems connected with the possible use of the surface water, but he calls attention to the existence of certain springs which are supplied with water percolating through the porous beds. Places where such springs are most likely to occur are pointed out and the problem of their occurrence and use is discussed. The general question of artesian water supply is also considered and the principles applied to this particular region where water is liable to be found in some of the porous layers of sediments and volcanic ash between the beds of lava. In fact, some artesian wells have already been bored in these beds. There is also a short section devoted to economic geology, in which attention is called to the existence of building stones, lignite, and the metals gold, silver, and copper.